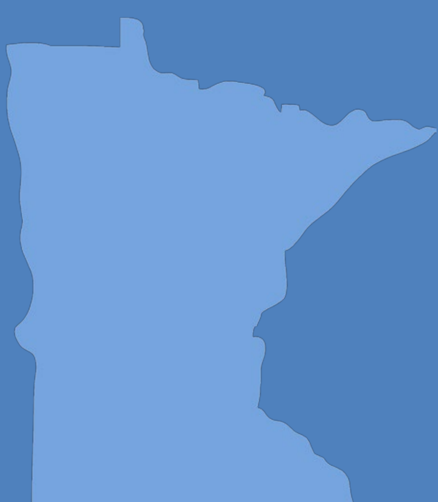
CLMP+ Report on Fleming Lake

(Aitkin County)

Lake ID# 01-0105-00
2015-2016 CLMP+ Data Summary



MINNESOTA POLLUTION CONTROL AGENCY

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Introduction

The Minnesota Pollution Control Agency (MPCA) conducts and supports lake monitoring activities to determine if water quality is suitable for recreational uses (swimming, wading, boating, etc.) of lakes. This information is also used to measure and compare regional differences and trends in water quality with lakes from all over the state. MPCA staff, local partners (soil and water conservation districts, watershed districts, tribal entities, etc.), and citizens all play a role in sampling lake water quality.

As part of the MPCA's Advanced Citizen Lake Monitoring Program (CLMP+), Terry and Sandy Dahlberg measured water quality in Fleming Lake from May-Sept ember in 2015 and 2016.

Figure 1. Aerial photo of Fleming Lake

Fleming Lake is located in Aitkin County, approximately 10 miles northwest of McGregor, Minnesota. It is 305 acres in size and has a maximum depth of 15 feet (4.6 meters). CLMP+ volunteers measured water transparency, collected temperature and dissolved oxygen (DO) profiles and collected water chemistry samples monthly. This report provides a summary of the water quality data and of other physical and ecological characteristics of the lake (Figures 1 and 2).

Ecoregion and land use characteristics

When investigating lake water quality, it is important to consider how land within the lake's watershed (the area of land surrounding the lake that drains water directly to it) is used. Certain uses of the land increase pollutant loading to the lake. For instance, phosphorus in animal waste can runoff from feedlots to surface waters

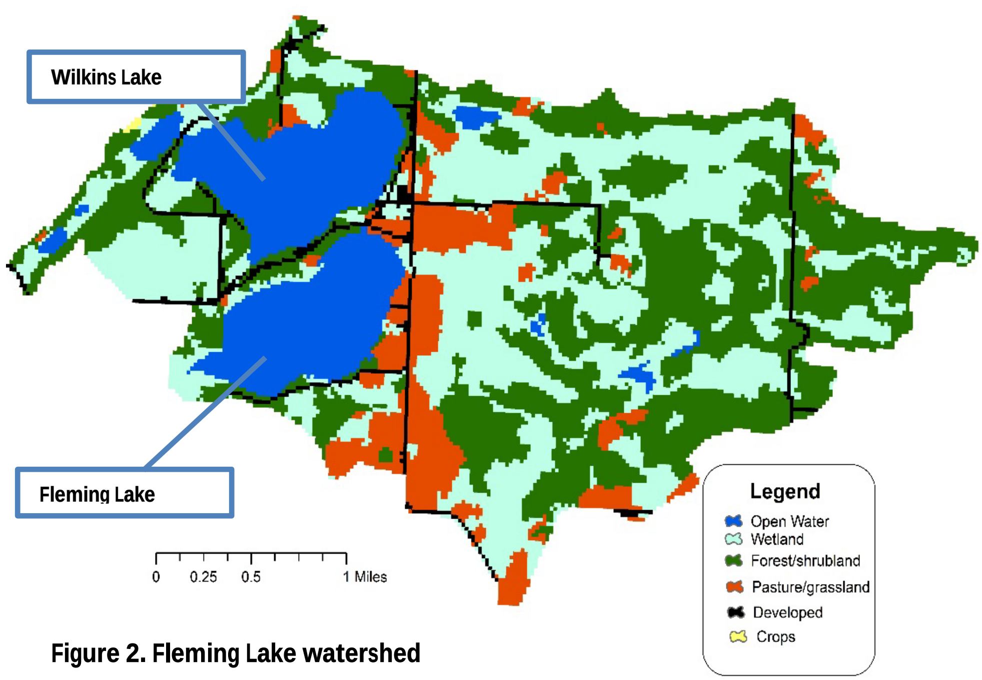

Figure 2. Fleming Lake watershed

during heavy rain events. Likewise, manure and commercial fertilizers can be washed from cultivated fields over land or through tiling systems to lakes. Additionally, phosphorus binds tightly to soil, so eroded soil from developed lakeshore or stream banks is often a large source of phosphorus to lakes and streams. Conversely, forested areas, undeveloped land, and wetlands are important features that preserve good water quality by serving as a buffer to filter water that flows across the catchment and into the lake.

Minnesota is divided into seven ecoregions, as defined by soils, land surface form, natural vegetation, and current land use. Fleming Lake is located in the Northern Lakes and Forest (NLF) ecoregion. Throughout this report, Fleming Lake characteristics are compared to the typical range of values from reference lakes within the NLF ecoregion. Fleming Lake has a watershed area of 4,627 acres. This is a small-sized watershed relative to the size of the lake (15:1 watershed: lake area ratio). Lakes with small watersheds relative to lake area often receive low water and nutrient loads; in contrast, those with large watersheds often receive high water and nutrient loads. In general, land use in the Fleming Lake watershed is very similar to the typical land uses found in the NLF ecoregion. Even though it does have slightly more pasture/grasslands and less forested land than is typical within this ecoregion it is balanced out by a greater percentage of open water and wetland areas. Watersheds dominated by forest and wetland typically deliver low amounts of nutrients to lakes.

Table 1. Land use composition

Land use	Fleming Lake watershed land use percentage	NLF typical land use percentage
Developed	4	0 – 7
Cultivated (Ag)	0	< 1
Pasture and open	10	0 – 6
Forest	37	54 – 81
Water and wetland	50	14 – 31
Feedlots (#)	0	

Lake mixing and stratification

Lake size, depth, and the shape of the basin affect whether a lake stratifies (forms distinct temperature layers) and how it mixes, which have a significant influence on water quality. Deep lakes that stratify during the summer months fully mix, or turn over, twice per year; typically in spring and fall. Shallow lakes (maximum depths of six meters or less), in contrast, typically do not stratify and mix continuously. Lakes with moderate depths may stratify intermittently during calm periods, but mix during heavy winds and during spring and fall. Mixing events allow nutrient-rich lake sediments to be re-suspended, which introduces phosphorus into the water where it may encourage the growth of algae, so lakes that continuously mix are at more risk of developing algal blooms than deeper lakes that stratify. Lakes that strongly stratify often have little or no oxygen near the lake bottom. Low oxygen can allow phosphorus to be released from the lake sediments, which is another way nutrients are introduced to the water and can stimulate the growth of algae. To determine if a lake stratifies or not, water temperature and DO are measured throughout the water column (surface to bottom) at selected intervals (e.g. every meter) several times during the open-water season. These measurements, called “profiles”, will reveal specific patterns if the lake stratifies and will also show how oxygen changes with depth.

To determine whether Fleming Lake stratified in the summer of 2015 and 2016, we plotted the monthly temperature and dissolved oxygen (DO) profile measurements taken onto scatter graphs (Figures 3, 4, 5

& 6). Figures 3 and 5 show relative consistency in temperature readings from surface to lake bottom in both 2015 and 2016, indicating the lake did not stratify in either year.

In 2016, dissolved oxygen also showed relative consistency from surface to bottom, except for July where DO levels were high at the surface and low near the bottom (Figure 6). This could indicate a high level of algae productivity in the lake during that time of year. Algae photosynthesizing at the water's surface produce oxygen, while decaying algae at the bottom of the lake deplete oxygen levels.

In 2015, however, DO levels did vary from surface to lake bottom (Figure 4). This can occur in lakes that are not thermally stratified when decaying algae or other biological activity eats up oxygen near the bottom. The lake bottom may also have been disturbed more regularly during anchor drops or due to the temperature/DO measuring device hitting the bottom during sampling sessions.

Because Fleming Lake does not stratify, it is considered to be polymictic, meaning that it mixes frequently. Shallow lakes are often polymictic and can be sensitive to excess nutrient levels since nutrients are continually dispersed throughout the water column through mixing rather than settling to the lake bottom.

In order for a lake to support cool and warm water game fish, a DO concentration of five milligrams per liter (mg/L) is necessary. The DO concentrations in Fleming Lake remained regularly above 5 mg/L in the well-mixed waters of the upper surface of the lake and appears to be enough to support a healthy fishery.

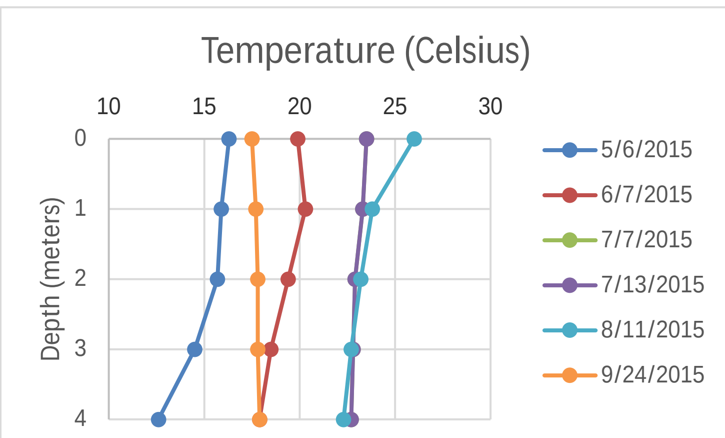

Figure 3. 2015 temperature profile

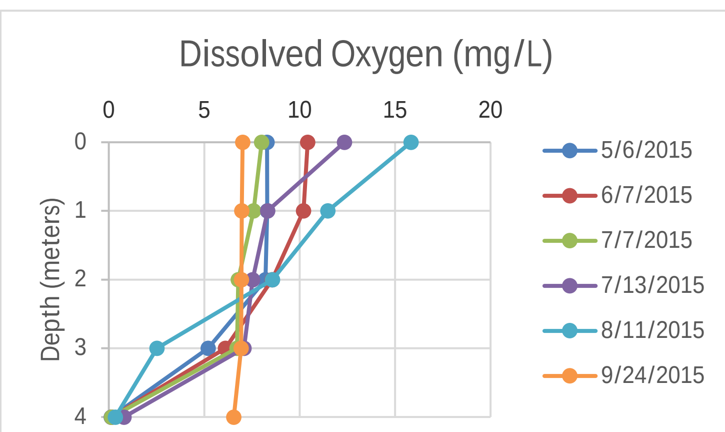

Figure 4. 2015 dissolved oxygen profile

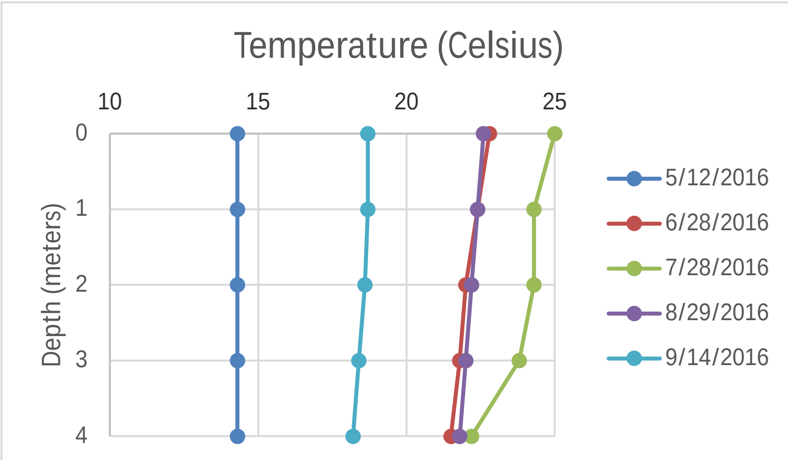

Figure 5. 2016 temperature profile

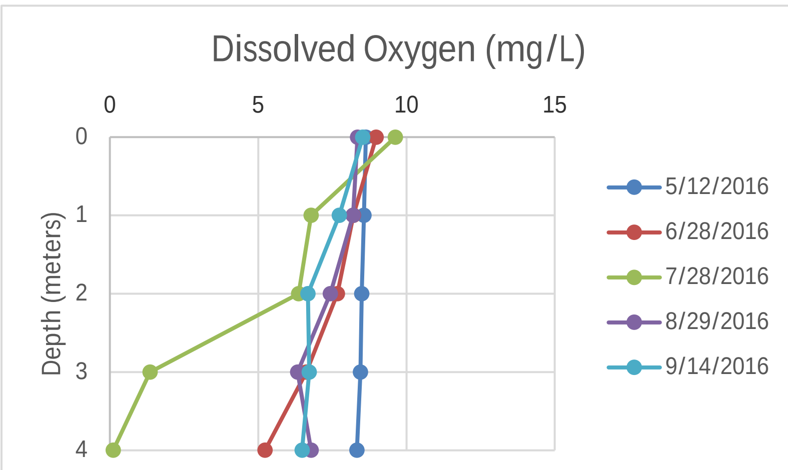

Figure 6. 2016 dissolved oxygen profile

Water quality

Nutrients, typically phosphorus and nitrogen, are the primary drivers of algal productivity in lakes. In general, high nutrient levels increase the likelihood that nuisance algal blooms will grow and that lakes will not support aquatic recreational uses; however, there are sometimes other factors at play that also must be considered.

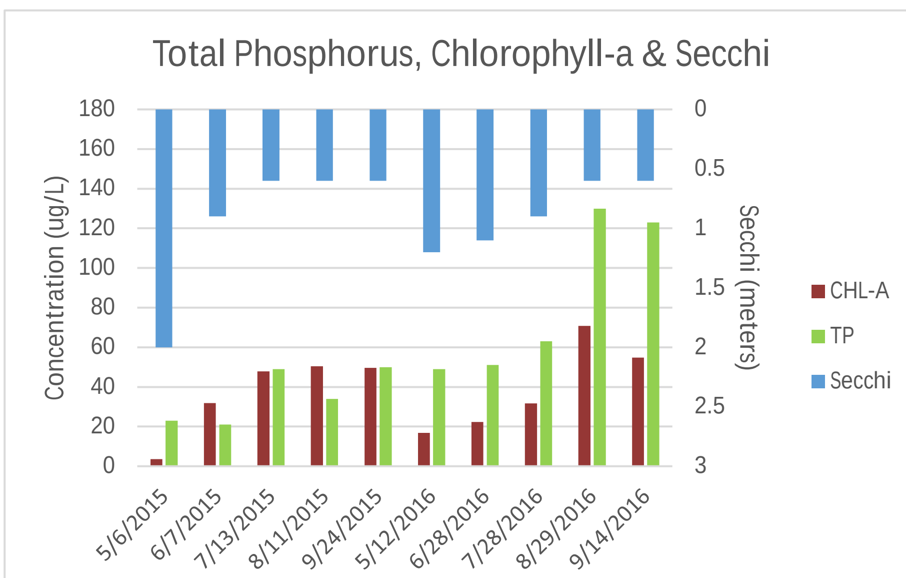

Figure 7. 2015 and 2016 phosphorus, chlorophyll-a, and Secchi

For this reason, it's important to collect information on suspended solids, temperature, DO, and a number of other parameters. All June-September water chemistry data for Fleming Lake gathered in 2015 and 2016 were averaged and compared to minimally impacted reference lakes in the NLF ecoregion (Table 2). References to lakes included in the last column in Table 2 include those selected to be typical of the ecoregion and minimally impacted, and allow for comparison to Fleming Lake.

Total phosphorus (TP) is often considered the nutrient that "limits" algal growth in lakes. This is because it is essential to algal growth and it is typically in the shortest supply. Fleming Lake's two-year summer average TP of 70 ug/L is much higher than the typical range for NLF lakes, which is 14-27 ug/L (Table 2). It is important to note that the average TP level in 2016 of 90 ug/L was significantly higher than the 2015 average of 40ug/L, which made an impact on the overall 2-year average. The 2016 TP average was the highest annual average to-date. In 1996, the average TP was 52 ug/L, in 2007 the average was 58 ug/L and in 2008 the average was 62ug/L. 2016 was a particularly wet year and Fleming Lake was likely impacted by increased runoff from the surrounding watershed — comprised largely of wetlands which can flush additional nutrients and organic material into the lake and cause an increase in total phosphorus levels.

Nitrogen, while also an essential nutrient for algal growth is typically not the "limiting nutrient" in most Minnesota lakes. Total Kjeldahl nitrogen is a measure of organic nitrogen (i.e., nitrogen found in algae) and ammonia- nitrogen. When combined with inorganic nitrogen, this represents total nitrogen (TN). Since inorganic nitrogen is often at or below detection in lakes, we often use total Kjeldahl alone to represent TN. The ratio of TN to TP is used as a simple basis for discerning which nutrient, TN or TP, is the limiting nutrient. Lakes are often considered "nitrogen-limited" when the TN:TP ratio falls below about 10:1. In the case of Fleming Lake its 22:1 TN:TP ratio is just below the typical range for NLF lakes, but still indicates that phosphorus is the nutrient controlling algal growth in this lake. The addition of phosphorus to the lake could increase the production of algae and aquatic plants.

Chlorophyll-*a* (Chl-*a*) (a pigment found in algae) is used to estimate the amount of algal production in a lake and, therefore, the lake's response to nutrients. As would be anticipated with the high TP results found in Fleming Lake, its Chl-*a* summer average of 45 ug/L was also high. With concentrations from 10-20 ug/L indicating a mild algal bloom and concentrations greater than 30 ug/L indicating severe nuisance conditions, algal blooms on Fleming Lake in 2015 and 2016 could have been a regular occurrence. Chlorophyll-a levels are increasing in the lake. In 1996 the average was 33 ug/L, in 2007 it was 34 ug/L and in 2008 it was 23 ug/L.

Table 2. Fleming 2015-2016 as compared to typical range for NLF ecoregion reference lakes

Parameter	Fleming Lake 2015 Average	Fleming Lake 2016 Average	Fleming Lake 2-year summer Average	Typical range for minimally impacted lakes in NLF
Number of reference lakes				32
Total phosphorus (µg/L)	40	90	70	14 – 27
Chlorophyll (µg/L)	45	45	45	4 – 10
Transparency (feet) (meters)	2.2 0.68	2.6 0.80	2.4 0.74	8 – 15 2.4 – 4.6
Total Kjeldahl Nitrogen (mg/L)	1.5	1.5	1.5	0.4 – 0.75
Chloride (mg/L)	2.9	2.6	2.8	0.6 – 1.2
Total Suspended Solids (mg/L)	13.3	12.4	12.8	< 1 – 2
TN:TP ratio	37:1	17:1	22:1	25:1 – 35:1

Chloride (Cl) for Fleming Lake was slightly higher than the typical range for NLF lakes (Table 2). The primary source of Cl to Minnesota lakes is winter application of road de-icing (road salt) compounds; however, other potential sources include water softeners, treated wastewater effluent, and seepage from septic systems. As noted in all lakes with development, Cl levels will likely continue to increase in the years to come since it is a conservative pollutant, meaning that it does not break down or leave the lake system over time. Chloride levels found in Fleming Lake are very low and impacts to aquatic life are not found unless concentrations are consistently above 200 mg/L.

Secchi transparency measures the depth of water clarity. Fleming Lake's two-year transparency average is significantly lower than the typical range for NLF lakes (Table 2 and Figure 8), which is expected with high levels of chlorophyll-a and total phosphorus. High total suspended solids, which may arise from suspended sediments (from runoff or wind mixing), can also limit transparency. Fleming Lake's average total suspended solids level of 12.8 ug/L is high and likely plays a role in limiting transparency. Much of the suspended solids in this lake are

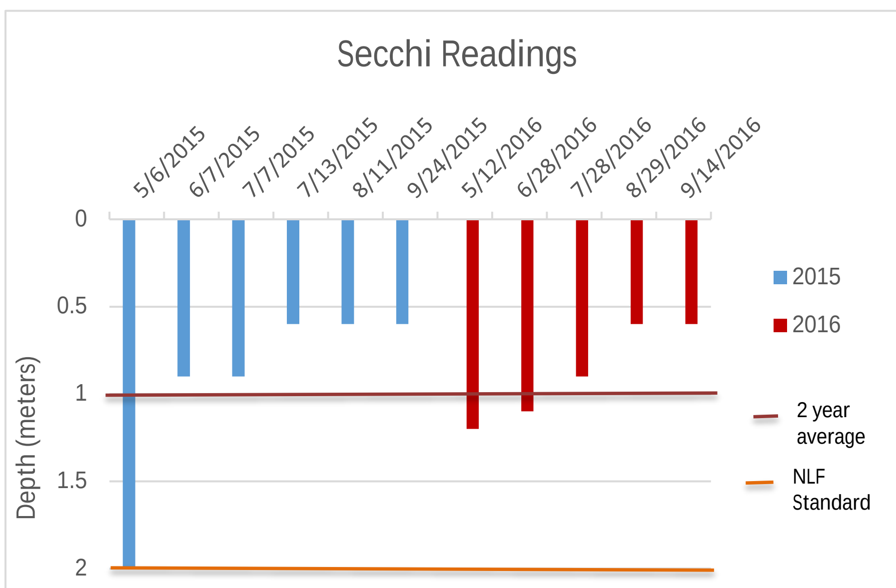

Figure 8. 2015 & 2016 Secchi readings

the result of dead algae, although, in periods of heavy rain or high winds, solids can be flushed from wetlands or stirred up from the lake bottom.

CLMP+ data collected for Fleming Lake show that in terms of TP, chlorophyll-a, and Secchi disk transparency, the water quality of the lake is poorer than the minimally impacted (reference) lakes in the ecoregion. Productive lakes such as Fleming are termed 'Eutrophic' lakes.

Trends

As part of the CLMP, citizens have monitored Fleming Lake for 22 years. The primary purpose of CLMP monitoring is to gather water clarity information for as many lakes as possible over a long period of time to determine if the water clarity trend for the lake is increasing, declining or remaining stable. At least 20 data points spread over eight years are required for a basic trend analysis, and more data are often needed to see an actual increasing or declining trend.

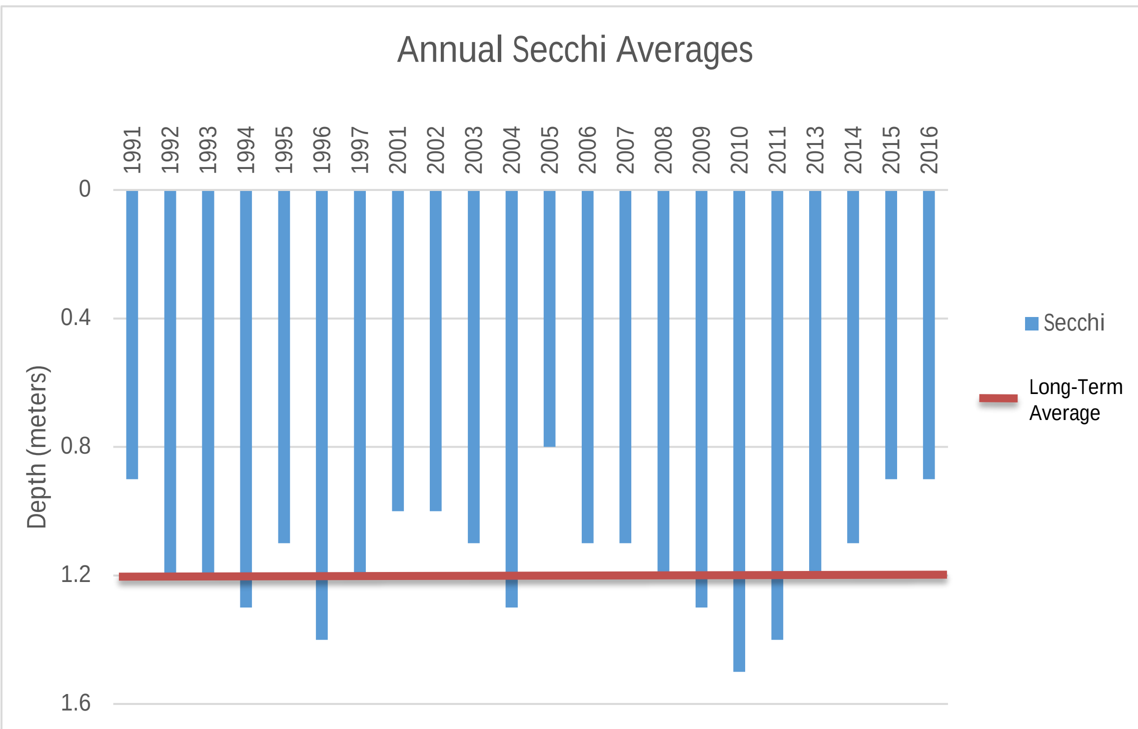

Figure 9 Long-term Secchi averages

Sufficient Secchi readings were collected on the Fleming Lake between 1991 and 2016 to run the trend analysis. Average transparency on Fleming Lake between 1991 and 2016 decreased by 0.11 feet per decade. Given the variability over these years, there is weak evidence of a possible long-term trend of declining water clarity. Water clarity in shallow lakes can often be highly variable depending on the fish community present, the success of the rooted plant community, and other factors. Fleming Lake reflects this, with periods of improved clarity, followed by years of poorer transparency. Continued participation in the CLMP program will be critical to helping gather the data necessary to monitor and track this trend.

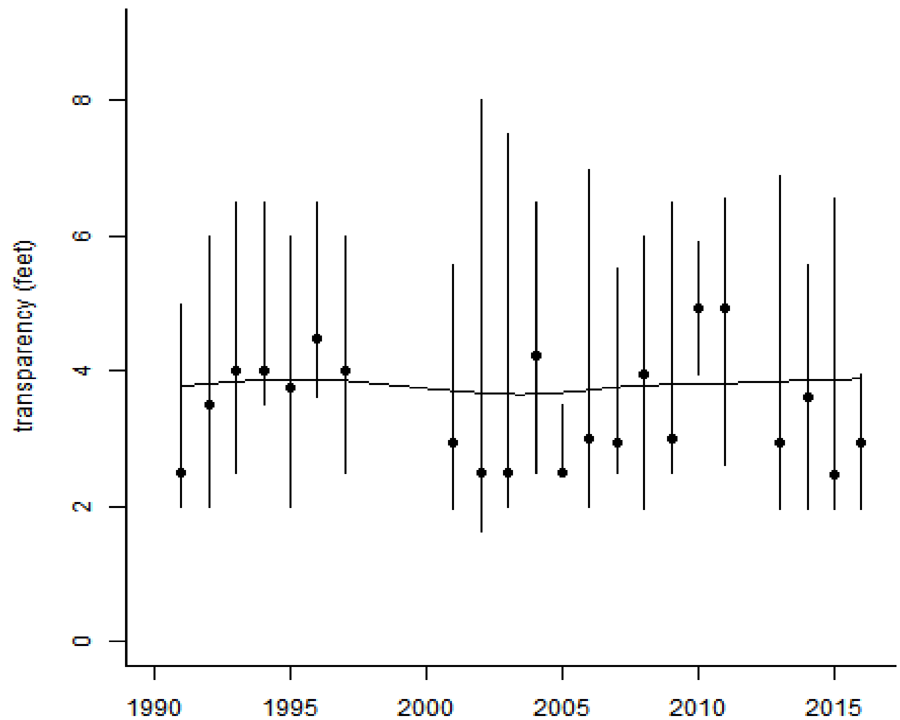

Figure 10. Secchi trend analysis

Summary

All of the water quality data from the MPCA's monitoring activities, those of its citizen volunteers and of other state and local partners, are gathered together and used to assess the condition of Minnesota lakes by determining if thresholds set to protect a lake's recreational uses (swimming, wading, boating, etc.) are being met. Annual assessments of lake and stream data are conducted on a rotating watershed basis. Fleming Lake is located within the Mississippi River-Brainerd major watershed, which the MPCA began monitoring in 2016. A second year of monitoring will take place in 2017 with water quality assessments complete by spring of 2018. All lakes and streams with sufficient data will be assessed by MPCA staff, including Fleming Lake.

Fleming Lake's water quality was first assessed back in 2009 and determined then not to be meeting state water quality standards due to an excess of nutrients. Based on water quality data collected as part of CLMP+ in 2015-2016, Fleming Lake is still not meeting state water quality standards (Table 3). After all water quality assessments are complete for the Mississippi River-Brainerd Watershed, lakes and streams not meeting state water quality standards, including Fleming, will be added to the state's impaired waters list and submitted to the federal Environmental Protection Agency for review and approval. From there, the MPCA will work with local partners to develop a Total Maximum Daily Load (TMDL) plan to identify the source of pollutants impairing Fleming Lake's water quality. Once the TMDL is complete, a restoration plan will be developed to reduce the level of nutrients entering the lake.

Table 3. A comparison of water quality data from Fleming Lake to the lake eutrophication standards for NLF ecoregion the.

	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Thresholds set to protect lakes in the NLF ecoregion for aquatic recreation use	<30	<9	>2.0
Fleming Lake 2-year summer averages	70	45	0.74

Engagement at the local level will be required to restore Fleming Lake's water quality.

Recommendations

- Continue to participate in the CLMP and regularly collect transparency data to provide the continuous water quality records needed for trend assessment.
- Participate in community meetings that will take place as part of the TMDL and lake restoration plan development process. Implementing restoration activities is spearheaded at the local level and volunteer participation is critical for long-term success.
- Minimize as much as possible the potential for phosphorus to be routed, or loaded, to the lake. This entails limiting lakeshore development (or utilizing good shoreland management during development) and retaining as much undeveloped land in the lake catchment as possible.
- Engage with county and township officials to ensure protection of wetlands in the surrounding watershed. Wetlands trap and filter sediments and nutrients, limiting their eventual run-off into Fleming Lake.
- Best management practices should be used when applying road deicers. Specifically, minimize the salting of roads near the lakes, and stockpile snow in upland areas away from the lakeshore.
- Maintain native aquatic plant beds to support fishery habitat and the quality and balance of the fish community. Native aquatic plants also provide natural wave breaks and results in decreased shoreline erosion. Increased wave action stirs lake sediments, clouding the water, making it difficult for new plants to grow. Healthy plant communities utilize available phosphorus and reduce the amount of it available for algae growth.
- Maintain remaining shoreline emergent aquatic vegetation – potentially important habitat for invertebrates and juvenile fish in addition to being a natural trap for washed in sediments and nutrients. Educate shoreland homeowners on the benefits of this habitat. The Minnesota Shoreland Management Guide (http://shorelandmanagement.org) provides useful information on this and other issues relevant to conserving the lake's beneficial uses.